CONTRIBUTIONS TO THE PLEISTOCENE FLORA OF NORTH CAROLINA[1]

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INTRODUCTION

During the summer of 1906, while engaged in a geological reconnaissance in North Carolina under the auspices of the Geological Survey of that state, two very interesting plant-beds of Pleistocene age were discovered, from which about forty different species of plants were collected. It is planned to describe and to fully illustrate these, together with future collections which it is hoped will be made, in a systematic volume devoted to the fossil remains of North Carolina; but, since it will be several years before this plan can be consummated, it seems desirable to publish a brief preliminary account of these plants, in so far as they have been determined, because of their by no means inconsiderable interest. To the geologist their chief interest is their bearing upon Pleistocene climates and their circumstantial evidence as to the very slight lapse of time, from a geological point of view, since glacial conditions came to a close. For the botanist they tend to show that some of the main elements in our present coastal plain flora, especially the arborescent forms, were already well defined in Pleistocene times, and that, while very likely a considerable part of the endemic herbaceous flora of the coastal plain has been differentiated in postglacial times, this theory cannot be extended to include many of the arborescent forms. The bulk of the following species are from a deposit on the Neuse River in Wayne County which I regard as of estuarine origin, laid down in post-glacial times, although it is quite possible that we have to deal with river deposits.[2]

[1] Published by permission of the North Carolina Geological Survey.

[2] Marine Pleistocene fossils occur near the mouth of the Cape Fear River, and an abundant marine fauna of Pleistocene age has been obtained from several artesian wells in New Hanover and Brunswick counties.

The assumptions on the part of the writer are drawn from the analogy of the Maryland and South Carolina Pleistocene, where an abundant marine fauna has been found. The locality along the Roanoke River will be referred to as Old Mill, and that on the Neuse River as station 850, the latter shown on the United States Engineers' blueprint map of the Neuse River. Citations will be made only of fossil occurrences.

ENUMERATION OF SPECIES

SPERMATOPHYTA

GYMNOSPERMAE

Coniferales

PINUS RIGIDA Mill.

Penhallow, *Transactions of the Royal Society of Canada*, Vol. X (1904), sec. 4, p. 69.

Characteristic leaves of this species, which are stout and stiff, some of them still in fascicles of three with the sheaths preserved, occur at station 850.

In the modern flora this species ranges from New Brunswick to Georgia, and west to Ontario and Kentucky, in dry sandy or rocky soil. It is a dominant form in the so-called "pine barrens" of New Jersey, and ranges farther north than do most of the members of the North Carolina Pleistocene flora. Wood has been recorded by Penhallow (*loc. cit.*) from a well-boring at Ithaca, N. Y.

The European Pleistocene contains several species based on foliage, cones, seeds and wood. In America *Pinus strobus* L. has been recorded from New Brunswick and Maryland, and *Pinus echinata* Mill from Maryland.

TAXODIUM DISTICHUM (L.) L. C. Rich.

Holmes, *Journal of Elisha Mitchell Society* for 1884–85, p. 92 (1885).

Berry, *Torreya*, Vol. VI (1906), p. 89.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 218, Plate 68.

Cypress swamps seem to have been a feature of the Pleistocene of the Atlantic coast. Several such, with stumps, knees, cones, and seeds, have been described from Maryland, and I am able to record another from near Rehobeth, Dela.[1]

[1] Communicated by Dr. C. K. Swartz.

Holmes (*loc. cit.*) records stumps up to six feet in diameter in a dark stiff clay beneath 18–20 feet of loam, laminated sands and clays, and marls, a few miles below New Bern on the Neuse River.

At station 850 were found many twigs and detached seeds. At Old Mill the twigs are common, and a rather poor cone impression was collected together with an unmistakable staminate ament.

ANGIOSPERMAE

Juglandales

HICORIA GLABRA (Mill) Britt.

Berry, *Torreya*, Vol. VI (1906), p. 89.

Occurrence based on a flattened nut and several husks from station 850. This species has been previously recorded from the Pleistocene of Virginia (nuts), and a small nut not specifically determined is recorded by Hollick from Maryland. The latter author also describes leaves of apparently this species under the name of *Hicoria pseudo-glabra* from the basal Pleistocene (Sunderland) of Maryland.

HICORIA OVATA (Mill) Britt.

Determination based on two incomplete terminal leaflets from station 850 which resemble this species more closely than they do those of any other modern hickory. In the living flora this species ranges from Quebec to Florida.

HICORIA SP. cf. *microcarpa* (Nutt.) Britt.

A hickory nut of larger size, much flattened and with a thin, apparently tardily dehiscent, husk was found at station 850. As yet it has not been satisfactorily correlated with any of the existing species.

Salicales

SALIX SP.

A single leaf of a willow was found at station 850. It has not been possible to satisfactorily determine its specific relations. The poplars which are well represented by three species of leaves in the Maryland Pleistocene have not yet been found in North Carolina.

Fagales

CARPINUS CAROLINIANA Walt.

Represented by numerous leaves from station 850. Similar remains are recorded from the basal Pleistocene of Maryland by

Hollick under the name *Carpinus pseudo-caroliniana*. The living *Carpinus orientalis* L. K. and *betulus* L. have been recorded from the Italian Pleistocene.

BETULA NIGRA L.

Knowlton, *American Geologist*, Vol. XVIII (1896), p. 371.

This species was very common at station 850, the remains including many leaves and some fragments of bark. Leaf impressions were also common in the clays at Old Mill. Recorded by Knowlton (*loc. cit.*) from the glacial terraces at Morgantown, W. Va.

The genus first appears in the Dakota sandstones, occurring also in the higher Cretaceous of North America and Greenland. It is largely developed in the Eocene, with over a dozen American species, the first European forms occurring at this horizon. Abundantly represented by numerous species in the Oligocene, Miocene, and Pliocene. Of the living forms *Betula lutea* Michx. has been recorded from the American, and *Betula nana* L. and *alba* from the European Pleistocene.

BETULA PSEUDO-FONTINALIS sp. nov.

Leaves in appearance very similar to those of the western *Betula fontinalis* of Sargent occur at station 850. The name given implies nothing more than the resemblance in leaf-form. This species may be characterized as follows: leaves ovate, with a broad truncate or rounded entire base; unusually long petiole and sparse secondary venation; margin indifferently serrate or dentate above.

FAGUS AMERICANA Sweet.

Berry, *Torreya*, Vol. VI (1906), p. 88.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 226. *Fagus ferruginea* (Michx.) Lesq.: *American Journal of Science*, Vol. XXVII (1859), p. 363; *Geology of Tennessee* (1869), p. 427, Plate 7 (K), Fig. 11. *Fagus ferruginea* Ait.: Knowlton, *American Geologist*, Vol. XVIII (1896), p. 371.

Leaves, nuts, and husks of this species are common at station 850. The beech is one of the commonest Pleistocene forms, and leaves, nuts, or husks have previously been recorded from both the oldest (Sunderland) and the youngest (Talbot) Pleistocene formations of Maryland, and from the Pleistocene of Tennessee, Virginia, and West Virginia.

QUERCUS PHELLOS L.

Leaves of the willow oak are common at station 850.

QUERCUS ALBA L.

Penhallow, *Transactions of the Royal Society of Canada*, Vol. X (1904), sec. 4, p. 74.

The leaves of the white oak are fairly common at station 850. Both leaves and wood are recorded by Penhallow from the Don River beds of Canada, and probably the same species under the name of *Quercus pseudo-alba* is recorded by Hollick from the Sunderland of Maryland.

QUERCUS LYRATA Walt.

Several leaves, together with four characteristic specimens of the acorns, of this species were found at station 850.

QUERCUS PALUSTRIS Du Roi.

Occurrence based on leaves from station 850.

QUERCUS PREDIGITATA sp. nov.

Leaves of the type of those of the Spanish oak—to which, however, it has seemed best to give a new name, since it is very probably the ancestral form, not only of this species, but of *Quercus pagodaefolia* (Ell.) Ashe as well—are abundantly represented at station 850. The leaves show gradations between *digitata* and *pagodaefolia*. Probably the same species is recorded by Knowlton from the glacial terraces at Morgantown, W. Va., under the old name *Quercus falcata* Michx.

QUERCUS ABNORMALIS sp. nov.

An abnormal oak leaf, bifid, with two linear lobes about one inch across. Based on a single specimen with the characteristic venation of *Quercus* from station 850. Leaf narrow, elongated, coriaceous; the blade divided about half-way up into two divergent lobes; margins entire.

QUERCUS MARYLANDICA Muench.

Several leaf specimens were collected at station 850.

QUERCUS NIGRA L.

Several leaf specimens from station 850.

QUERCUS PRINUS L.

Leaves fragmentary for the most part, but common, station 850.

QUERCUS PLATANOIDES (Lam.) Sudw.

Several leaf specimens from station 850. It is, of course possible —I might say, probable—that the leaves of this and the preceding represent the variable leaves of their common Pleistocene ancestor, not yet differentiated into dry and moisture loving forms.

QUERCUS PRINOIDES Willd.

Leaves which apparently represent this species occur at station 850, although it is impossible to determine their exact relation to the two preceding forms.

ULMUS ALATA Michx.

Several leaves of this modern southern type were found at station 850. Two species of *Ulmus* are known from the Sunderland of Maryland; *Ulmus betuloides* Hollick, possibly representing the modern *Ulmus americana* L., and *Ulmus pseudo-racemosa* Hollick, representing the modern *Ulmus racemosa* Thomas. The latter also occurs at Morgantown, W. Va., and in the Don River deposits of Canada, where it is associated with *Ulmus americana.*

PLANERA AQUATICA (Walt.) J. F. Gmelin.

This southern type in the modern flora is represented by two or three rather unsatisfactorily determined leaves from station 850. The related, if not identical *Planera ungeri* Ettings is recorded from the Sunderland of Maryland.

Ranales

BERBERIS SP.

A single leaf, apparently a barberry, but not specifically determinable, was found at station 850.

Rosales

LIQUIDAMBAR STYRACIFLUA L.

Hollick, *Bulletin of Torrey Club*, Vol. XIX (1892), p. 331.

Knowlton, *American Geologist*, Vol. XVIII (1896), p. 371.

Liquidambar europaeum Al. Br., Lesq.: *Proceedings of U. S. National Museum*, Vol. XI (1888), p. 36.

The sweet or red gum is sparingly represented at station 850 by two or three fragmentary leaves and one flattened fruit-head. Previously recorded from Morgantown, W. Va., by Knowlton, and from Bridgeton, N. J., by Lesquereux and Hollick. I should expect this

species to be more common in the North Carolina Pleistocene than it is. Its rarity, however, may be one of the exigencies of preservation, since I have noticed that the modern gum leaves decay much more rapidly than do most other leaves, judging by their comparative state of preservation in the recent leaf-rafts and leaf-beds along the North Carolina rivers.

PLATANUS OCCIDENTALIS L.

Knowlton, *American Geologist*, Vol. XVIII (1896), p. 371.

Penhallow, *Transactions of the Royal Society of Canada* (II), Vol. II (1896), sec. 4, pp. 68, 72.

Platanus aceroides Göpp.: Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 231, Plates 73, 74.

Fragmentary leaves of this species were common, and one flattened "buttonball" was found at station 850.

This seems to have been one of the common types of the Pleistocene. Recorded from the Sunderland, or oldest Pleistocene, of Maryland, as well as in the interglacial Don River deposits of Canada and the glacial terraces at Morgantown, W. Va. The Carolina leaves average somewhat smaller than do those of the modern tree.

RUBUS SP.

Based on a small branch with characteristic prickles, found at station 850.

MALUS CORONARIAFOLIA sp. nov.

Leaves triangularly ovate with acute apex and rounded base, 4^{cm} by 3.1^{cm}, with four or five incised lobes on each side, the margins finely salient-serrate. Based on leaves very like those of the American crab apple, *Malus coronaria* (L.) Mill, found at station 850. Besides these leaves there are others somewhat resembling the modern *Malus angustifolia*, but not yet positively determined.

CRATAEGUS SPATHULATOIDES sp. nov.

Based on leaves like those of the modern small-fruited haw, *Crataegus spathulata* Michx; which they resemble so closely that further specific characterization is unnecessary. Collected at station 850.

CRATAEGUS COCCINEAFOLIA sp. nov.

Based on leaves and thorns preserved in the lignitic layers, and so like those of the modern scarlet thorn, *Crataegus coccinea* L., that further specific characterization is unnecessary at this time.

It is probable that both this and the preceding still exist, but since the modern thorns have been segregated into such a maze of species, it was not thought profitable to attempt any closer identification of these two Pleistocene forms.

Sapindales

ILEX OPACA Ait.

Hollick, *Bulletin of Torrey Club*, Vol. XIX (1892), p. 331.

Based on two characteristic leaves from station 850. Recorded by Hollick along with *Ilex cassine* L. from Bridgeton, N. J.

The genus is an old one, ranging back to the Mid-Cretaceous, and apparently somewhat composite in character. A species of the Prinos section is recorded from the Pleistocene of Kentucky, and the genus is also represented in the European Pleistocene.

Rhamnales

VITIS SP.

This occurrence is based on a tendril preserved at station 850.

Grapes were apparently common during the Pleistocene, although heretofore represented only by their very characteristic seeds, which have been recorded by the writer from the Virginia Pleistocene, and by Hollick from four different localities in the Maryland Pleistocene. Two Pleistocene species are recorded from Europe.

Thymeleales

PERSEA PUBESCENS (Pursh) Sargent.

This southern swamp form is represented by two leaves from station 850.

Umbellales

NYSSA BIFLORA Walt.

Berry, *Torreya*, Vol. VI (1906), p. 90.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 235, Plate 69, Fig. 5.

Nyssa caroliniana Poir: Hollick, *Bulletin of Torrey Club*, Vol. XIX (1892), p. 331.

North Carolina representation includes leaves from station 850 and seeds from Old Mill. Previously recorded from the late Pleistocene of Virginia and Maryland, being represented by both leaves and seeds in the latter state. Leaves have been recorded from Bridgeton, N. J., and the writer has recently collected the seeds in the clays at Fish House, N. J.

Ericales

XOLISMA LIGUSTRINA (L.) Britt.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 236, Plate 69, Fig. 6.

Fossil forms of this type of leaf are usually referred to the genus *Andromeda* of Linnaeus, and many species are recorded, ranging from the Mid-Cretaceous to the present. Lesquereux records two species (*dubia* and *vaccinifoliae affinis*) from the Pleistocene of Somerville, Tenn. The present species was found at station 850. It has been previously recorded from the late Pleistocene (Talbot) of Maryland.

DENDRIUM PLEISTOCENICUM sp. nov.

Based on leaves from station 850. They are of coriaceous texture, and are identical with those of *Dendrium hugeri*, which has been separated by Small from the old species *Dendrium buxifolium* (Berg.) Desv., in which the leaves are smaller.

It seems likely that the modern *Dendrium hugeri*, which is a form of the mountains of western North and South Carolina, is directly descended from this Pleistocene form, and that *Dendrium buxifolium*, which is a "pine-barren" form with reduced leaves, and which ranges from New Jersey to Florida, is a later specialization in that habitat.

VACCINIUM CORYMBOSUM L.

Hollick, Maryland Geological Survey, *Pliocene and Pleistocene* (1906), p. 236, Plate 69, Figs. 7–9.

Specimens of leaves of this species occur both at station 850 and at Old Mill. Previously recorded from the late Pleistocene (Talbot) of Maryland.

VACCINIUM SPATULATA sp. nov.

Based on spatulate leaves of this generic type found at station 850. Length 2.4^{cm}, width 1.2^{cm}. Somewhat coriaceous with two or three remote camptodrome secondaries on each side.

CONCLUSIONS

Attention is arrested by the remarkable development of the oaks in this flora, there being eleven species in all, or nearly 29 per cent. of the known flora; and if it be objected that some of the determinations, such as the recognition of *prinus*, *prinoides*, and *platanoides*, will not stand, there still remains an unusually large showing, possibly to be explained by the fact that oak leaves are more coriaceous and resist maceration better than do most leaves.

It will be seen at a glance that the enumerated flora as given above contains no boreal or even cool temperate elements. All of the species which in the modern flora range northward into New England or Canada also range southward to Georgia and Florida, with but two exceptions—*Pinus rigida*, whose present southern range is Virginia, and *Quercus prinoides*, whose present southern limit is North Carolina. Southern Delaware and Maryland mark the northern limit of *Taxodium distichum;* New Jersey marks the northern limit of *Quercus lyrata, digitata, nigra, Nyssa biflora*, and *Dendrium;* while *Quercus phellos* and *marylandica* do not get beyond Long Island, and *Liquidambar* dies out in Connecticut. On the other hand, *Ulmus alata* does not get north of Virginia, and *Persea pubescens* and *Planera aquatica* do not get north of North Carolina.

There are nine distinctly swamp and low river-bank forms, two additional forms of low moist woods besides *Liquidambar* and *Platanus*, which make their best growth in humid wooded regions. The forms which in the living flora are denizens of dry sandy or rocky soils are *Pinus rigida, Quercus phellos, digitata, nigra, prinoides*, and *marylandica.*

While it is always perilous to estimate the temperature in degrees from fossil faunas or floras, and it would be rash indeed to assert that, since some of these forms do not range above North Carolina in the living flora, the temperature of the Pleistocene in this region would have a minimum of 40° to 44°. However, from the floral grouping as a whole I think it may safely be concluded that the temperatures were not lower than they are at the present time in the same latitude, and, if anything, they were slightly higher, with as great humidity as prevails at the present time in the coastal plain of North Carolina.

These results agree with those arrived at by Pugh[1] from a study of the Mollusca from the Pleistocene of South Carolina. Additional facts pointing to the same general conclusion are the former northward extension of *Taxodium*, and the occurrence of *Planera aquatica* in the Pleistocene of Maryland. That these floras did not flourish in mild interglacial periods is indicated by their association in Maryland with ice-borne bowlders of considerable size, the origin of some of which has been traced, the direction of movement discrediting forces other than those of ice-action. A further fact is the occurrence of several of these species in the West Virginia glacial terraces. Some of these terraces contain remains of the musk-ox and other pronounced boreal types, and are undoubtedly of glacial origin. Those with fossil plants are not so satisfactory, as they contain few species of northern affinities, and might be taken to illustrate interglacial conditions, although they do not indicate as mild a climate as do the fossiliferous interglacial beds in the valley of the Don, near Toronto, Canada. These considerations somewhat weaken their evidence in this connection. They are here denominated as "glacial," following the original description by I. C. White and Knowlton, with the reservation that close stratigraphical studies may subsequently show that the plant-bearing terraces differ in age from those with boreal animal remains, as the contained flora in a measure indicates, although not altogether inconsistent with the published view of their glacial age.

To be sure, the North Carolina deposits were many miles south of the terminal moraine, and the local ice which may have been developed, while it proved equal to the task of transporting bowlders, did not exercise any considerable effect upon the temperatures of the lowlands. Cobb has suggested[2] that the cobbles found along the "banks" of the Carolina coast were transported by icebergs from New England during periods of maximum glaciation and are not of local origin. By implication this theory might include all the erratics in the marine Pleistocene of the southern coastal plain. Such a conclusion seems, however, extremely improbable.

[1] G. T. Pugh, *Pleistocene Deposits of South Carolina*, Thesis, Vanderbilt University, 1905.

[2] C. Cobb, *Journal of Elisha Mitchell Society*, Vol. XXII (1906), p. 18.

We know that the land was low and that the country was densely wooded, with a high humidity, all of which are factors that ameliorate temperatures, so that persistent ice in comparatively low latitudes, if present at all, seems to have been almost entirely a question of moderate cooling in the highlands, combined with unbalanced precipitation, while the climate of the low-lying coastal plain, even as far northward as Maryland, did not differ greatly from what it is at present.